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Better use of nitrogen for barley under zero tillage

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Better use of nitrogen for barley under zero tillage

S.S. MALHI
Agriculture Canada
Research Station
Lacombe, Alberta

M. NYBORG
Department of Soil Science
University of Alberta
Edmonton, Alberta

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SUMMARY

Zero tillage produces lower crop yield than conventional tillage in central and north-central Alberta when N fertilizer is broadcast. Field experiments were conducted to determine reasons for lower yields under zero tillage than conventional tillage and to investigate methods to reduce yield difference between zero and conventional tillage. The result showed that lower yields under zero tillage were due to the fact that surface-applied urea N did not become fully available to plants because the fertilizer N was too far away from the crop roots; probably some N was lost through ammonia volatilization. When urea was placed in bands near the seed row, the availability of applied N to plants improved, and barley yields under zero tillage were equal to or greater than conventional tillage.

RÉSUMÉ

Dans le nord et le centre de l'Alberta, l'azote épandue en nappe sur semis direct produit un rendement net plus bas que sur labour conventionnel du sol. Des essais en plein champs ont été entrepris pour en déterminer la cause. Les résultats indiquent que le rendement sur sol sans labour à été causé par la non-disponibilité de l'azote uréique pour les racines des plantes et par une perte d'azote due à la volatilisation de l'ammoniac. Par contre, lorsque l'urée est placée en bandes près des lignes de semis, la disponibilité de l'azote appliquée augmente et le rendement de l'orge sur semis direct est supérieur ou égal à celui sur labour conventionnel.

INTRODUCTION

It is now known that zero tillage[1] increases organic matter in soil, improves soil tilth and conserves water. It has also lower labour, fuel and machinery requirements and is one of the most effective methods for preventing soil erosion. To compare zero and conventional tillage systems for barley production in central Alberta, field experiments were established at four locations in the fall of 1978. However, zero tillage produced consistently lower barley yield than conventional tillage when N fertilizer was broadcast (Table 1). To be economically attractive to producers, zero tillage must be equal or more productive than conventional tillage. Field experiments were conducted in central and north-central Alberta on Gray Luvisol and Black Chernozem soils to determine the reasons for the lower yields under zero tillage compared to conventional tillage and to investigate methods to reduce the yield gap between zero and conventional tillage. The results of those experiments are reported in this bulletin.

Table 1. Grain yield of barley under zero and conventional tillage (average of 5 years).

Tillage treatment	Grain yield (kg/ha)			
	Lacombe	Joffre	Crestomere	Blackfalds
Zero	3678	3017	2432	2510
Conventional	3968	3435	2635	3172

CLIMATE OF THE STUDY AREA

The area has a mean annual precipitation of 450 to 500 mm. The soils in this area usually are frozen and snow-covered from November to March or early April. About 60% of the total precipitation comes during growing season from May to August.

IMPROVING EFFICIENCY OF SPRING-APPLIED UREA

Two field experiments were carried out with labelled urea fertilizer to determine why yields are lower under zero tillage compared to conventional tillage. The N recovery by barley with surface-broadcast application of labelled urea under zero tillage was lower than the N recovery with incorporation of the urea under conventional tillage (Table 2). Apparently, availability of applied N was less to barley under zero tillage because the position of fertilizer N was away from the crop roots compared to conventional tillage.

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[1]Zero tillage refers to planting a crop directly into untilled soil, while in conventional tillage the soil is cultivated to prepare a seedbed.

Table 2. Influence of tillage and method of placement on the recovery of labelled urea (50 kg N/ha) in barley.

Method of placement	Recovery of labelled urea (%)			
	Rimbey		Ellerslie	
	Zero-Till†	Conv-Till	Zero-Till	Conv-Till
Broadcast‡	22.3	31.8	32.2	39.5
Bands 23 cm	40.2	40.3	47.4	51.2
Bands 46 cm	42.4	39.9	50.2	53.3
Nests 23 cm	47.9	43.4	50.2	52.4
Nests 46 cm	43.7	54.2	53.4	51.3

† Zero-Till and Conv-Till refer to zero tillage and conventional tillage, respectively.
‡ Broadcast refers to surface-broadcasting under zero tillage and incorporation under conventional tillage.

The lower yields under zero tillage were at least partially due to the inefficient use of fertilizer N by the crop. There was probably less downward movement of the surface-applied N to the crop roots and possibly some losses of N through ammonia volatilization, prior to fertilizer entry to the soil.

In the labelled urea experiments, band placement below the soil surface was used to improve accessibility of applied N to crop roots and to eliminate any N loss by volatilization. The N recovery in barley plants increased substantially when urea was placed in bands, and more so in nests[2] at the Rimbey site (Table 2). The results on the recovery of applied N in soil indicated that banding or nesting was more effective in decreasing the amount of fertilizer N which was immobilized in soil than surface-broadcasting or incorporation.

In experiments where broadcast and band placement of urea were compared for grain yield, the yield increase from broadcast applied N was lower under zero tillage treatments than conventional tillage at Rimbey (Table 3). However, when urea was banded, zero and conventional tillage produced similar yield responses to applied N. Banding 5 cm directly below the seed row tended to produce slightly more yield than side banding (banding 4 cm beside and 4 cm below the seed row) under conventional tillage. The Innisfail experiment (more fertile Black Chernozem soil) showed banding superior to surface-broadcasting in some years.

In two other experiments, urea was side banded at time of sowing at 0, 33, 67 and 100 kg N/ha under zero and conventional tillage (Table 4). Barley yields under zero tillage were equal or greater than conventional tillage at the 67 or 100 kg N/ha rates, though zero tillage produced lower yields at low rates of urea N. Yield increases

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[2]Nesting is a method of application where fertilizer granules are placed together at a point below the soil surface - also called point placement, or large pellets or granules, or super pellets or granules.

Table 3. Increase in grain yield of barley from applied N under various tillage-straw-treatments following different methods of placement with urea applied at 67 kg N/ha over a 6-year period at Rimbey.

Method of placement	Tillage-straw treatments			
	Straw-removed		Straw-retained	
	Zero- Till†	Conv- Till	Zero- Till	Conv- Till
	-------------- Increase in grain yield (kg/ha) --------------			
Broadcast‡	1191	1427	1224	1379
Side band	1490	1415	1561	1493
Below seed††	1495	1554	1525	1587

†Zero-Till and Conv-Till refer to zero tillage and conventional tillage, respectively.
‡Broadcast refers to surface-broadcast under zero tillage and incorporation under conventional tillage.
††Below seed refers to banding directly, 5 cm below the seedrow.

Table 4. Yield of barley grain under various tillage-straw treatments at four levels of urea N side banded at time of sowing over a 5-year period.

Location	Tillage-straw treatments		Grain yield (kg/ha)			
	Tillage	Straw	0 N‡	33 N	67 N	100 N
Rimbey	Zero	Removed	1491	2071	2912	3294
	Conv†	Removed	1600	2281	2961	3015
	Zero	Retained	1350	2086	3016	3424
	Conv	Retained	1613	2264	3006	3180
Innisfail	Zero	Removed	2727	3170	3575	3832
	Conv	Removed	3123	3318	3683	3790
	Zero	Retained	2506	2940	3664	3878
	Conv	Retained	2656	3196	3627	3917

† Conventional tillage.
‡ kg N/ha.

(fertilized plot minus zero-N plot) from applied N were greater under zero tillage than conventional tillage particularly at 67 and 100 kg N/ha rates. Thus, the banded N fertilizer was more effective in increasing yields under zero tillage.

In summary, banding urea near the seed reduced the yield gap between zero and conventional tillage. In our other studies, we have also found that tilled soils accumulated much more nitrate-N than zero-tilled soils, but the accumulated nitrate-N can be partially

lost. Therefore, another advantage of zero tillage is that loss of nitrate-N released from native soil N can be reduced by zero tillage and thereby improving N fertility of soils.

IMPROVING EFFICIENCY OF FALL-APPLIED UREA

In central Alberta, the effectiveness of spring-applied urea under zero tillage was increased substantially by placing the fertilizer in bands near the seed at time of sowing. However, in the prairie provinces, N fertilizers are frequently applied in the fall instead of the spring for spring-sown cereals. This is because of lower fertilizer prices in fall and a reduction in the spring workload. In field experiments conducted on tilled soils in central Alberta, the soil incorporation of fall-applied N was less effective than similarly applied N in the spring. The performance of fall-applied urea N was improved by placing the N fertilizer in bands or nests. Information on N placement and recovery under zero tillage was sparse. Therefore, field experiments were conducted in central Alberta on zero tillage to compare grain yield and recovery of applied N with broadcasting, banding and nesting of urea applied in the fall.

In two field experiments labelled urea was used to study the fate of fall-applied N under zero tillage (Table 5). The recovery of the labelled urea in barley was lowest with surface-broadcast application at both locations. The N recovery with fall broadcasting was lower than spring broadcasting. Placing urea in bands, and more so in nests, improved the N recovery considerably. Fall N recoveries were similar to spring N recoveries. Less fertilizer was immobilized in the organic matter when the N fertilizer was banded or nested. This resulted in more applied N left for plant uptake with banding or nesting as compared to surface-broadcasting.

Table 5. Influence of time of application and method of placement on the recovery of labelled urea (50 kg N/ha) in barley under zero tillage.

		% Recovery of labelled urea (%)				
Location	Time of application	Surface-broadcast	Bands 23 cm apart	Bands 46 cm apart	Nests 23 cm apart	Nests 46 cm apart
Rimbey	Fall	13.4	20.8	21.8	34.0	41.3
	Spring	22.4	40.2	42.4	47.9	43.7
Ellerslie	Fall	28.7	40.1	42.3	42.2	43.1
	Spring	32.2	47.4	50.2	50.2	53.4

In two other field experiments barley was grown for grain yield with commercial urea at 50 kg N/ha following various methods of application (Table 6). When urea was applied in the fall under zero tillage, the surface-broadcast application resulted in the lowest barley yield. Yield increased markedly when the N fertilizer was placed in bands 23 cm apart. Fall broadcasting gave lower yields than spring broadcasting. The 46 cm

bands or nesting of pellets produced slightly less yield than 23 cm spaced bands. The grain yields with fall banding were equal to, or greater than, spring banding. Like the barley yield, the N-use efficiency of fall-applied N was also markedly higher with 23 cm spaced bands than surface-broadcast application. The N-use efficiency from fall banding (23 cm) was approximately 1.5 times greater than fall broadcasting. The other placements (46 cm) were less effective than 23 cm banding but more effective than surface-broadcasting.

Table 6. Effect of method of placement on yield of barley grain and N use efficiency with urea applied at 50 kg N/ha in fall under zero tillage.

Treatment		Grain yield (kg/ha)		N-use efficiency (kg grain/kg N/ha)	
Time of application	Method of placement	Rimbey	Innisfail	Rimbey	Innisfail
Fall	Broadcast†	1916	3031	16.5	16.3
Fall	Bands 23 cm	2382	3333	25.8	22.4
Fall	Bands 46 cm	2159	3197	21.4	19.7
Fall	1g pellets	2221	3321	22.6	22.1
Fall	2g pellets	2074	3367	19.7	23.1
Control		1091	2214		

† Surface-broadcast.

Barley yields were lowered with increasing band spacing beyond 23 cm or nesting of pellets because their proximity to the N source was too great. During the growing season in all years many of the plants growing away from the N fertilizer bands or nested pellets showed visual N-deficiency symptoms with reduced growth; while the plants growing near or directly above the bands or nested pellets were dark green and tall. This uneven growth was more evident at Rimbey (where N was limiting for plant growth) than at Innisfail. Apparently, urea in 46 cm bands or in nested pellets did not diffuse far enough to nourish all plants equally.

Previous experiments have shown more over-winter nitrification of urea when applied in early fall (i.e. late September) than in mid (middle October) or late fall (late October or early November). Fall-applied urea in 46 cm bands or in nested pellets under zero tillage probably is more effective if N is applied very early in the fall.

In summary, for fall-applied urea under zero tillage, surface-broadcasting was least effective and methods of application which minimized soil-fertilizer contact were most effective in increasing yield of barley. The results suggest that banding or nesting has the potential to significantly improve the efficiency of fall-applied N under zero tillage, as long as the spacing is not too wide.

CONCLUSIONS

Fertilizer banding technique may allow farmers in central Alberta, or elsewhere, to produce crops under zero tillage with yields equivalent to those obtained under conventional tillage.

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